TWELFTH INTERNATIONAL CONFERENCE OF RADIATION,
NATURAL SCIENCES, MEDICINE, ENGINEERING, TECHNOLOGY AND ECOLOGY
JUNE 17-21, 2024
HUNGUEST HOTEL SUN RESORT, HERCEG NOVI, MONTENEGRO

Fractionated Stereotactic Radiation Therapy for Large Intracranial Tumors: Plan quality

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INTRODUCTION

- Stereotactic radiosurgery (SRS) has been used in the management of primary small brain tumors including meningiomas, vestibular schwannomas, pituitary tumors and brain metastases.
- There may be selected cases, where radiosurgery is inappropriate because of tumor location and tumor size within the brain. Treatment in multiple fractions of stereotactic radiosurgery, termed as fractionated Stereotactic Radiotherapy (fSRT), potentially provides both adequate tumor control and low toxicity rates. (1,2 3)
- SRS and fractionated Stereotactic Radiotherapy (fSRT) utilize the stereotactic frames and multiple planar or non- coplanar arc beams, by delivering a concentrated dose in tumor with steep dose gradients external to the treatment volume.

- This study aims to report a clinical experience of fractionated stereotactic radiation therapy (FSRT) for intracranial tumors by evaluating the plan quality as dose coverage, conformity index and plan physical parameters.

METHODOLOGY

- Stereotactic fractionated radiosurgery treatment plans for 10 patients with diagnosis of meningiomas, a pituitary adenoma, a vestibular schwannoma and brain metastases, treated at XKnife Unit at University Hospital “Mother Teresa” Tirana, were selected and evaluated retrospectively.
- The stereotaxic system Gill –Thomas- Cosman frame and Computed Tomography (CT) localizer supported to the BRW ring were securely attached to the patient head by Velcro strips for patient immobilization . The BRW *CT localizer is* equipped with nine rods that will appear in the axial slice image as dots (6).

Figure1. Stereotactic GTC frame b) BRW localizer CT frame; axial patient image with 9 rods visible CT localizer and axial CT image of a patient (BPU)

- *Treatment planning* were performed using Integra XKnife Treatment Plan System (TPS), by Radionics USA.
- The gross target volume (GTV) for each patient and organs at risk were delineated in CT images of slice thickness of 1-1.25 mm and controlled with fusedMRI images.
- Planning target volume (PTV) was defined as GTV, for low grade intracranial tumors (meningioma, vestibular schwannoma, pituitary adenomas) and with an additional margin of 1 mm in tumor of higher grades.
- The dose prescription to PTV was made to the 90% isodose line which is placed around the edge of the target [RTOG].

- Fractionation schemes of 20 - 25Gy in 5 fractions for benign tumors and 20-21 Gy in 3-5 fractions for brain metastases.

- The dose prescription to PTV was made to the 90% isodose line which is placed around the edge of the target [RTOG].
- FSRS consists of using multiple noncoplanar arcs of circular shaped beams converging on to the machine isocenter, which is stereotactically is placed at the center of imaged target volume.
- A Linear Accelerator Oncor Impression, Siemens with 6 MV FF and 7 MV FFF photon beams has been used for the treatment with added cone collimators, 12.5 mm to 40 mm in diameter, precisely machined which comes closer to patient by minimizing geometric penumbra.
- A spherical dose distribution obtained in this case can be shaped to fit the lesion more closely by manipulating several parameters: changing arcs, angles and weights, using more than one isocenter or more than one cone . Optimization of some of these parameters is carried out automatically by the TPS.
- During treatment, Depth helmet and Winston- Lutz test were used for isocenter and setup verification in repositioning.

Xknife Treatment planning system

Patient verification

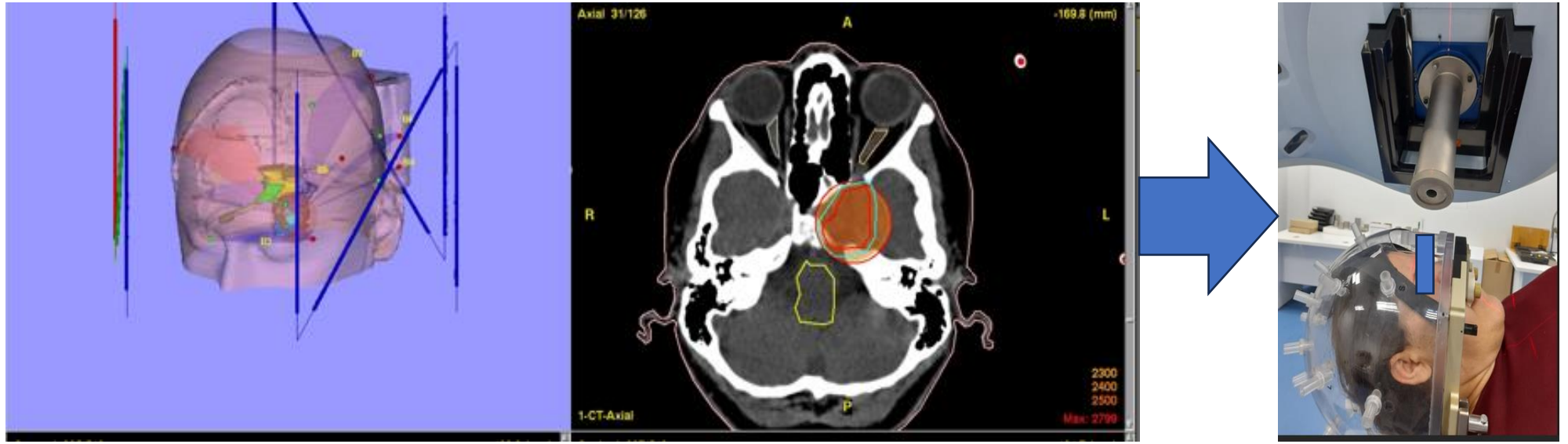


Figure 2. 3D view of patient image in Integra Xknife. CT axial image of patient with the dose distribution to the PTV. Patient positioning with Depth helmet before dose delivering performing by plan.

- Plan evaluation is based on dose-volume histograms for tumor coverage with the prescribed isodose level while keeping dose constraints for organs at risk.
- From dose - volume histogram has been estimated the dose coverage to the prescription isodose to the target volume.
- The conformity index (CI) at the prescription isodose to the target volume PITV recommended by (RTOG) is defined as the ratio of the prescription isodose volume PITV over the target volume TV and is automatically calculated form Integra XKnife TPS.

Organ at risk dose constraints	
Three- fraction treatment	
Optic nerves chiasma	$V_{(15\ Gy)}$ < 0.2 cc D_{max} < 19.5 Gy
Cochlea	D_{max} < 20 Gy
Brainstem	$V_{(18Gy)}$ < 1 cc D_{max} < 23 Gy
Five- fraction treatment	
Optic nerves, chiasma	V(20Gy) <0.2 cc D_{max} <25 Gy
Cochlea	Dmax < 27 Gy
Brainstem	$V_{(26Gy)}$ < 1 cc Dmax < 31 Gy

- Stereotactic fractionated radiosurgery treatment plans for 10 patients with diagnosis of meningiomas, a pituitary adenoma, a vestibular schwannoma and brain metastases has been selected and evaluated retrospectively. fSRS treatment have been considered for the patients because of large tumor volumes (> 3 cc) or tumors adjacent to the organs at risk less.

- The fractionated SRS prescribed dose has been at 90% isodose level with typical fractionation schemes of 25Gy in 5 fractions for benign tumors and 20-21 Gy in 3-5 fractions for brain metastases. In planning with FSRT treatments Linac-based, the isocenter is usually placed at the center of PTV.

- Beam configurations were realized with the aim that the prescribed dose in 90 % isodose level to cover at least 95 % of the the PTV volume.

- Evaluation of treatment plans were performed by controlling dose distribution to the target in the axial slices, and dose coverage and conformity index from Dose-volume histograms.

RESULTS AND **DISCUSSION ….**

- Ten patients treated with fSRS with diagnosis of meningioma (5 cases), a vestibular schwannoma, a pituitary adenoma and three brain metastases were selected for plan evaluation. Tumor volumes were in the range **of 3.3 cc to 20.6 cc, with a mean value 10.3 ± 6.1 cc located adjacent to organs at risk as brainstem and optic pathways.**

- In cases of meningiomas of irregular lesion shape, two isocenter were used. Treatment plans were realized by using photon beams with the energy of 6 MV and 7 MV. Tertiary cones collimator sizes used were from 27.5 mm to 40 mm in diameter. For achieving a good coverage and conformity there were used four to six non-coplanar Arc fields, with 40 to 100 degree per arc, starting and finishing to avoid entry or exit through the eyes.

- Monitor units (MU) per fractions , vary by the fractional dose as well from the depth tumor localization within the skull. For 5 Gy per fraction are delivered 690-834 MU with a mean value of 763 ± 55.6 MU, and for a 7 Gy are delivered 1129MU.

- Based on dose volume histograms of these treatment plans the values of dose coverage to the PTV-s were in the range 92.8 % – 97.8 % with a mean value 94.6 ±1.6 %.

- CI values of ten cases were in the range of 1.3 – 2.9 with a mean value of 2.0 ± 0.6. according to RTOG it is achieved an optimal mean value of CI. (1.0<CI < 2.0)

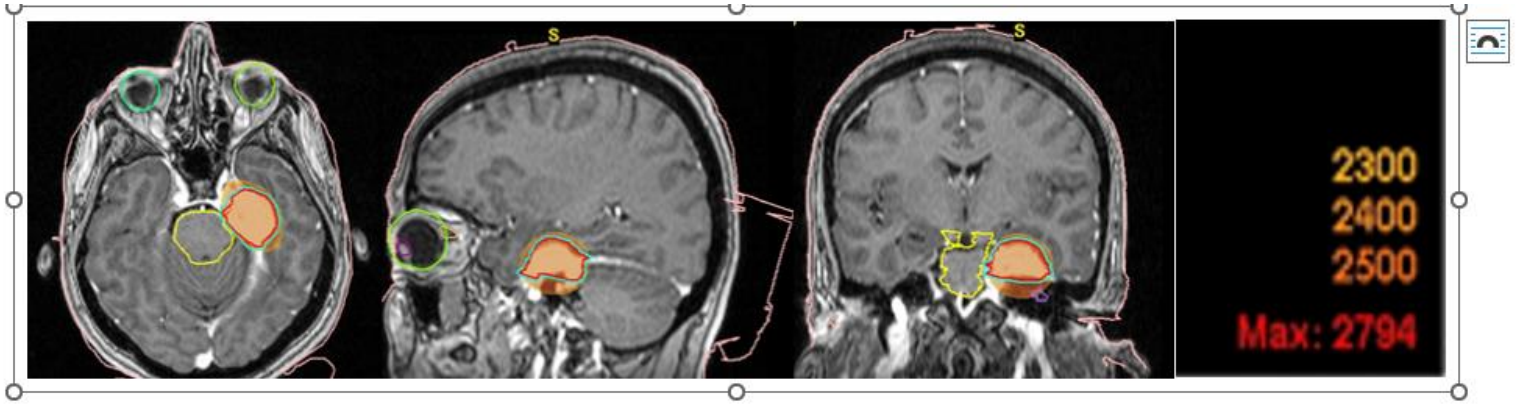
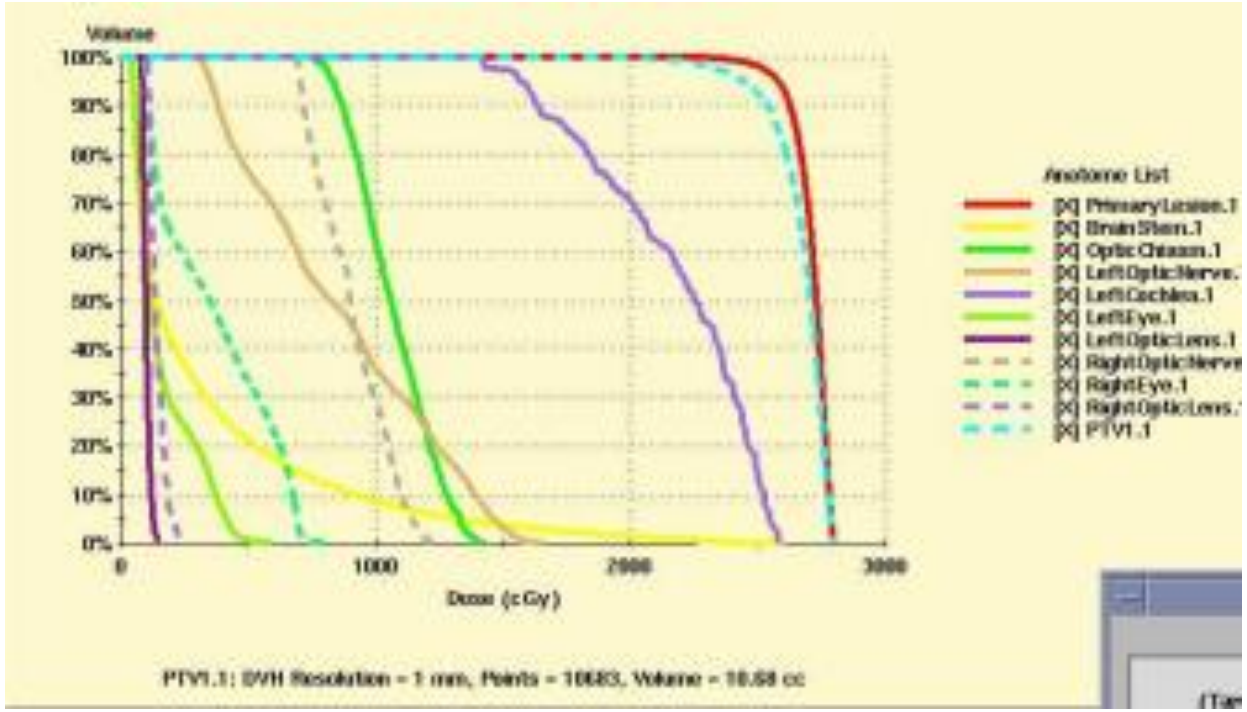


Figure 3. Dose distribution on MRI images. FSRS to a 10.8 cc left meningioma treated with 25 Gy in 5 fractions with 1 mm margin.

Dose volume histogram



CONCLUSION

- Ten patients treated with fSRS with diagnosis of meningioma (5 cases), a vestibular schwannoma, a pituitary adenoma and three brain metastases were selected for plan evaluation. Tumor volumes were in the range of 3.3 cc to 20.6 cc, with a mean value 10.3 ± 6.1 cc located adjacent to organs at risk as brainstem and optic pathways.

- Dosimetric results for the ten patients show that, the *target dose coverage* were in the range 92.8 – 97.8 % with a mean value 94.6 ±1.6 % and the Conformity Index values in the range of 1.3 – 2.9, with a mean value of 2.0 ± 0.6. According to RTOG (7) these values indicate optimal dosimetric results.

- The conformal fractionated stereotactic radiotherapy using XKnife-5 -TPS system with relocatable Gill-Thomas-Cosman frame tertiary cones Linak based, provides a safe and effective treatment to the large volume intracranial tumors and critically located to brain organs at risk.

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11. Tolerance of Normal Tissue to Therapeutic Radiation.Dr Emami B

Thank you !